

# School of Computer Science and Engineering

Accredited by ABET (B.S. in Computer Science, BS in Computer Engineering)

## School of Computer Science and Engineering

Jack Brown Hall, Room 307  
(909) 537-5326 Computer Science and Engineering website (<http://cse.csusb.edu>)

### Bachelor of Arts

Computer Systems

- With options in:
- General Interdisciplinary
- Game Development
- Graphics Programming
- Web Programming
- System Administration

### Bachelor of Science

Bioinformatics  
Computer Engineering  
Computer Science

### Minor

Computer Science

### Certificate Program

Computer Systems and Programming

### Master of Science

Computer Science

Computer science is a discipline with historical foundations in science, mathematics and engineering. It is concerned with the study of a variety of topics including computer design, computer programming, information processing, data communication, machine intelligence, robotics, the algorithmic solution of problems, and the various representations of information including numeric, alphabetic, visual, audio and sensory. This discipline deals with effective ways to represent and display information, algorithms to process information, languages in which to express algorithms, hardware systems to interpret such languages, theoretical techniques for insuring the accuracy and cost effectiveness of these processes and the philosophical foundations of computing and machine intelligence.

The Bachelor of Science in Computer Science degree program is accredited by ABET/CAC. The program emphasizes the fundamentals of computer science and the skills required to apply computer science to application areas, as well as professional ethics. The objective of the program is to prepare the student upon graduation for: immediate entry into a programming, software engineering, systems and network administration or similar position in either the public or private sectors; or

for graduate education in computer science or a closely related discipline leading to a master or doctoral degree.

The Bachelor of Science in Computer Engineering is accredited by ABET/EAC. Computer engineering is a discipline with historical foundations in computer science and electrical engineering. It is concerned with the study of a variety of topics including circuit design, programmable logic, computer design, computer programming, software engineering, data communication, machine intelligence, robotics, the algorithmic solutions of problems, and the various representations of information including numeric, alphabetic, visual, audio, and sensory. This discipline deals with effective ways to represent and manipulate information, algorithms to process information, hardware systems and technologies to run software, design methodologies for hardware and software systems, and engineering techniques for ensuring the accuracy and cost effectiveness of these processes.

The Bachelor of Science in Bioinformatics provides students with a background and skills useful for research and development in the growing biotechnology industries. Bioinformatics is the interdisciplinary study of biology and biochemical systems using mathematics and computer science. It involves the use of computers and statistics to make sense out of large amounts of data that are accumulating from high-throughput biological and chemical experiments, such as sequencing of whole genomes, DNA, microarray chips, two-hybrid experiments, and tandem mass spectrometry. The bioinformatics degree program is a collaboration between the School of Computer Science and Engineering, the Department of Biology and the Department of Chemistry and Biochemistry.

The Bachelor of Arts in Computer Systems program emphasizes the application of principles to practical problem solving in a domain of interest. Students complete a core set of foundation courses and coursework in one of the following concentrations: web programming, system administration, game development, graphics programming. Students also have the ability to combine the study of computer systems with another field of study through the general interdisciplinary option.

The Minor in Computer Science is designed to give students from all academic disciplines a foundation in computing which will enrich and support the student's own field of study.

The Certificate Program in Computer Systems and Programming is a short course of study provided for those individuals who desire a career in the computer science field which does not require a formal degree.

### School Honors

Candidacy for honors in your major voluntary and must be applied for at the beginning of the senior year. The department will determine whether a student is to be awarded departmental honors based upon the following criteria. Other factors may also be taken into account when designating honors.

### School Honors in Computer Science or Computer Systems

1. Demonstration of independent work by achieving a grade of "C" (2.0) or better in a four-unit CSE 595. Independent Study or credit in CSE 575. Internship in Computer Science;
2. Attainment of a minimum overall grade point average of 3.0 ("B") in all university courses attempted and a minimum grade point average of 3.5 in all computer science courses required by the major (as defined above);

3. At least five upper-division computer science courses required by the major must be taken at this university.

#### School Honors in Computer Engineering

1. Demonstration of independent work by achieving a grade of "C" or better (2.0) in any one of the following:
  - a. CSE 575. Internship in Computer Science (4)
  - b. CSE 595. Independent Study (4)
  - c. PHYS 585. Internship in Physics (4)
  - d. PHYS 595. Independent Study (4)
2. Attainment of a minimum overall grade point average of 3.0 ("B") in all university courses attempted and a minimum grade point average of 3.5 in all computer science courses required by the major.
3. At least five upper-division computer engineering courses required by the major must be taken at this university.

#### School Honors in Bioinformatics

1. Demonstration of independent work by completing an internship or independent study through the School of Computer Science and Engineering, Department of Biology or Department of Chemistry and Biochemistry.
2. Attainment of a minimum overall grade point average of 3.0 ("B") in all university courses attempted and a minimum grade point average of 3.5 in all courses required by the major.
3. At least five upper-division courses required by the major must be taken at this university.

### Current Faculty

George M. Georgiou, Professor  
B.S.E.E. 1985, Louisiana Tech University  
M.S.E.E. 1987, M.S. 1988, Louisiana State University  
M.S. 1990, Ph.D. 1992, Tulane University

Ernesto Gomez, Professor  
B.A. 1969, Cornell University  
M.S. 1975, Universidad de Puerto Rico  
Ph.D. 2005, University of Chicago

Yasha Karant, Professor  
B.A. 1975, Immaculate Heart/Cal Tech  
M.S. 1978, Ph.D. 1981, University of California, Berkeley

Josephine G. Mendoza, Professor  
B.S. 1974, M.Eng. 1977, University of the Philippines  
Ph.D. 1984, University of Illinois

Owen J. Murphy, Professor  
B.A. 1979, Holy Cross  
M.S. 1982, Worcester Polytechnic Institute  
Ph.D. 1985, Syracuse University

Haiyan Qiao, Associate Professor, Chair  
B.S. 1993, M.S. 1996, Huanzhong University, China  
M.S. 2002, North Dakota State University  
Ph.D. 2007, University of Arizona

David A. Turner, Professor  
B.S. 1980, Wichita State University  
M.S. 1983, University of Massachusetts  
Ph.D. 2001, Institute Eurecom, Sophia Antipolis, France

Kerstin Voigt, Professor, Director  
Vordiplom 1981, Johann-Wolfgang-Goethe University of Frankfurt, Germany  
M.S. 1984, Ph.D. 1994, Rutgers University

Tong L. Yu, Professor  
B.S. 1977, Chinese University of Hong Kong  
M.S.E. 1982, Ph.D. 1986, Johns Hopkins University

Kay Zemoudeh, Professor  
B.S. 1981, M.S. 1984, University of Southwestern Louisiana  
Ph.D. 1990, University of South Carolina

### Emeritus

Arturo I. Concepcion, Professor

## Undergraduate Degrees

### Bachelor of Arts

- Computer Systems (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/computer-systems-ba>) with options in:
  - General Interdisciplinary
  - Game Development
  - Graphics Programming
  - Web Programming
  - System Administration

### Bachelor of Science

- Bioinformatics (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/biology/bioinformatics-bs>)
- Computer Engineering (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/computer-engineering-bs>)
- Computer Science (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/computer-science-bs>)

## Graduate Degree

### Master of Science

- Computer Science (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/computer-science-ms>)

### Minor

- Computer Science (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/computer-science-minor>)

## Certificate Program

- Computer Systems and Programming (<http://bulletin.csusb.edu/colleges-schools-departments/natural-sciences/computer-science-engineering/computer-systems-programming-certificate>)

## Courses

### CSE 122. Bioinformatics. 2 Units.

(GE=B4)

Introduction to natural sciences and its interplay with computer science. Description of bioinformatics and the application of computer science and problems in the life sciences.

### CSE 125. Programming in Visual Basic. 4 Units.

Programming techniques in an event-driven and object-oriented environment. Graphical user interfaces, controls, properties, procedures, and functions. Multiple forms, menus, file access, and applications. Three hours lecture and two hours activity laboratory. Materials fee required.

### CSE 129. Science, Computing and Society. 2 Units.

(GE=B4)

Understanding physical science in terms of information and information processing. Use of computer as both a tool and metaphor for understanding life, physics, and existence, and its implications and impact on society and ethics.

### CSE 140. Introduction to Game Design. 2 Units.

Elements of games, including theme, game play and presentation. The process by which game concepts are transformed into actual computer games, including the use of scripting languages to incorporate sound and graphics into a game, design documents, project management, evaluation, game play parameters and artificial intelligence. Several examples will be used to demonstrate game design concepts and practice. One hour lecture and two hours laboratory. Material fee required.

### CSE 141. Introduction to Game Level Editing. 2 Units.

Basic concepts on level editing of games and how a game is fine-tuned and balanced to improve gameplay and fun. Use of a level editor to demonstrate application of physics and artificial intelligence is included. One hour lecture and two hours laboratory. Materials fee required.

### CSE 201. Computer Science I. 4 Units.

Prerequisites: Some prior computer programming experience, or CSE 125  
Computer software design, implementation, methods and environments using a current high-level language. Survey of computers, applications and other areas of computer science. Three hours lecture and two hours activity laboratory. Materials fee required.

### CSE 202. Computer Science II. 4 Units.

Prerequisites: CSE 201 with a grade of C or better  
Analysis of problems and the formulation, documentation and implementation of their solutions; an introduction to data structures with abstract data types; software engineering principles for both individual and group projects. Three hours lecture and two hours activity laboratory. Materials fee required.

### CSE 208. Introduction to Computer Engineering Design. 2 Units.

Prerequisites: Consent of Instructor

(GE=B4)

Introduction to the principles in engineering design and design issues of sustainability, environmental impact, human interface, accessibility and inclusive of a product, and effectiveness of the technique. One hour lecture and three hours laboratory. Materials fee required. Formerly CSE 406, CSE 152 and PHYS 152.

### CSE 292. JAVA Programming. 4 Units.

Prerequisites: prior course in computer programming  
Study of object oriented programming and techniques using JAVA programming language.

### CSE 303. Computer Engineering Design. 1 Unit.

Prerequisites: CSE 208

Guided engineering design activity on an ongoing real world problem. Three hours activity. Must be repeated for a total of seven units.

### CSE 308. Computer Engineering Design. 4 Units.

Prerequisites: CSE 208

Guided engineering design activity on an ongoing real world problem. Three hours lecture and three hours laboratory. Formerly CSE 407 and CSE 303.

### CSE 310. Digital Logic. 5 Units.

Prerequisites: CSE 202 and MATH 272

Boolean algebra, flip-flops, combinational and sequential circuits, arithmetic-logic units, memory devices, and I/O peripherals. Laboratory experiments include bread-board assembly of finite state machine circuits, registers and arithmetic-logic processors. Four hours lecture and three hours laboratory. Materials fee required.

### CSE 311. Advanced Digital Design. 4 Units.

Prerequisites: CSE 310

Transistor circuits, MOS and CMOS characteristics, design of logic families, CPLDs and FPGAs, timing, propagation, hazards, bistability and metastability, ASM charts, skew, reliability and testing, and transmission line behavior. Materials fee required. Three hours discussion and three hours laboratory.

### CSE 313. Machine Organization. 4 Units.

Prerequisites: CSE 202

Typical components of von Neumann computer architectures; their organization, interrelated activities and control are emphasized and demonstrated using low-level languages. Three hours lecture and two hours activity laboratory. Materials fee required.

### CSE 320. Programming Languages. 4 Units.

Prerequisites: CSE 202

Topics include formal language specification, data types and their implementation, abstract mechanisms, control structures, run-time representations and storage management. Several high-level languages will be examined. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 322. Web Page Programming. 4 Units.**

Prerequisites: CSE 202 or consent of instructor

Current protocols, technology, languages, and methodologies for the browser side of web-based systems; performance issues; human factors, page and site design. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 330. Data Structures. 4 Units.**

Prerequisites: CSE 202 with grade of C or better and MATH 272 or MATH 372

Abstract data structures including lists, stacks, queues and trees; their storage allocation and associated application algorithms. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 335. Signals and Systems. 4 Units.**

Prerequisites: MATH 213 and MATH 331

Fundamentals of signal and system analysis, including representations of discrete-time and continuous-time signals and representations of linear, time-invariant systems. Topics include complex exponentials and geometrics, differential equations, Fourier representation, Laplace and Z transforms, frequency responses, etc.

**CSE 360. Script Programming. 4 Units.**

Prerequisites: CSE 201

Getting started; terminal types; e-mail; command line and GUI interfaces; advanced editing; macros; text processing and programmers tools. Two hours lecture and four hours activity laboratory. Materials fee required.

**CSE 365. Systems Administration. 4 Units.**

Prerequisites: CSE 201

Responsibilities and skills of the system administrator; managing accounts, system files and mail; security, reliability and backups; emergencies; ethics and usability. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 366. Systems Networking. 4 Units.**

Prerequisites: CSE 365

Planning and configuring networks; file transfer; network file servers; bridges and routers. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 401. Contemporary Computer Architecture. 5 Units.**

Prerequisites: CSE 310 and CSE 313

Design methodology; processor units and control units of von Neumann computer architectures; RISC architectures, including pipelining and parallel-processing. Laboratory experiments consist of the use of computer-aided design tools for VLSI layout and simulation. Four hours lecture and three hours laboratory. Materials fee required.

**CSE 403. Circuit Design and Analysis. 4 Units.**

Prerequisites: CSE 310, MATH 251, and PHYS 150

Analysis and design of digital and analog circuits, active and passive elements, diodes, FET and BJT transistor circuits, introduction to VLSI, two port networks, transmission lines, three phase circuits, filtering circuits in continuous and discrete time, Laplace and Z transform analysis and design, spectrum and power characterization of signals and systems. Three hours lecture and three hours activity laboratory. Materials fee required.

**CSE 405. Server Programming. 4 Units.**

Prerequisites: CSE 322

Current operating system technology; languages and methodologies of controlling servers; performance analysis; interfaces to databases; security, monitoring, and maintainability. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 408. Sustainable Engineering Design. 4 Units.**

Prerequisites: CSE 308

(GE=B5)

Guided engineering design project on an ongoing real world problem. Examines issues of sustainability, energy, pollution, ethics, accessibility and effects of products on various stakeholders, analysis of designs and failure modes, as well as technical report writing and presentations. Three hours lecture and three hours laboratory. Materials fee required.

**CSE 420. Computer Graphics. 4 Units.**

Prerequisites: CSE 330 and MATH 331

Survey of computer graphics hardware. Topics include animation, two-dimensional and three-dimensional transformation, hidden surface removal algorithm, business charts and applications.

**CSE 431. Algorithm Analysis. 4 Units.**

Prerequisites: CSE 330 and MATH 372

Analysis and design of algorithms, including time and space complexity, design methodologies, and taxonomic classification of problems. Formerly CSCI 331.

**CSE 440. Game Design. 4 Units.**

Prerequisites: CSE 330

Study of game design concepts and game design specification. Topics include principles of user interface layout, game design techniques, game design methodologies, artificial intelligence in gaming, and game design tools.

**CSE 441. Game Programming. 4 Units.**

Prerequisites: CSE 330

Techniques and technology used to produce games. Topics include game engine design, mathematical foundations of game programming, game physics, artificial intelligence, and application of software engineering principles to a game development environment. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 455. Software Engineering. 4 Units.**

Prerequisites: CSE 330

Advanced techniques and technology used to produce large software systems. Laboratory work with a software development environment. Three hours lecture and three hours laboratory. Materials fee required.

**CSE 456. Embedded Systems. 4 Units.**

Prerequisites: CSE 310 and CSE 313

Theory and practice of software and hardware co-design, including microcontrollers, embedded programs, real-time operating systems, and low-resources system design. Three Hours lecture and two hours activity laboratory. Materials fee required.

**CSE 460. Operating Systems. 4 Units.**

Prerequisites: CSE 313 and CSE 330

An overview of operating systems. Principles of resource management and control. Multiprogramming, distributed systems and multiprocessor systems will be included. Three hours lecture and two hours activity laboratory. Materials fee required.

### **CSE 461. Advanced Operating Systems. 4 Units.**

Prerequisites: CSE 460

File systems, I/O systems, Security Distributed systems. Three hours lecture and two hours activity laboratory. Materials fee required. Formerly CSE 350, students may not receive credit for both.

### **CSE 482. Senior Interdisciplinary Project. 4 Units.**

Prerequisites: consent of the department

Analysis, design and implementation of a software system that solves an interdisciplinary problem related to the student's chosen program option or minor field of study. Presentation techniques and communication skills to support project planning and execution.

### **CSE 488. Ethics and the Computing Professional. 2 Units.**

Prerequisites: senior standing

Professionalism, ethics, legal issues and the social impact and role of computer technology.

### **CSE 489. Senior Seminar. 2 Units.**

Prerequisites: completion of all required 300-level computer science courses for the B.S. in Computer Science degree

A series of weekly seminars covering a wide range of computer science topics and formats including presentations from industry and university personnel, and students regarding projects and research work. Graded credit/no credit.

### **CSE 500. Introduction to Formal Languages and Automata. 4 Units.**

Prerequisites: CSE 431 or consent of instructor

Introduction to formal language theory. Finite state machines, regular grammars, context-free grammars, context-sensitive grammars, push-down automata, closure properties.

### **CSE 501. Introduction to Theory of Computation. 4 Units.**

Prerequisites: CSE 500 or consent of instructor

Theoretical foundations of computer science: deterministic and non-deterministic Turing machines, models of computation; recursive functions, Church's thesis and undecidable problems; complexity classes P, NP, CO-NP and PSPACE. Formerly CSCI 546.

### **CSE 510. Advanced Computer Architecture. 4 Units.**

Prerequisites: CSE 401

High performance computer architectures and algorithms including pipeline, vector, array, multiprocessor computer designs, applications, and programming. Also covered are data flow and systolic machines, interconnection networks, and graph and parallel graph algorithms. Three hours lecture and two hours laboratory. Materials fee required.

### **CSE 511. Expert Systems. 4 Units.**

Prerequisites: CSE 330

Expert systems components, problems and applications. Knowledge bases, inference engines, and their integration within expert systems. Tools for building expert systems, system algorithms as related to hardware, implementation languages and examples of systems in operation. (4 units).

### **CSE 512. Introduction to Artificial Intelligence. 4 Units.**

Prerequisites: CSE 330

Problems and issues of artificial intelligence, current techniques and methods, and future prospects of machine intelligence. Three hours lecture and two hours activity laboratory Materials fee required.

### **CSE 513. Advanced Artificial Intelligence. 4 Units.**

Prerequisites: CSE 512 or consent of instructor

Advanced issues and techniques in artificial intelligence; intelligent agents for problem solving, reasoning and learning; advanced artificial intelligence programming in LISP. Three hours lecture and two hours activity laboratory. Materials fee required.

### **CSE 514. Computational Intelligence. 4 Units.**

Prerequisites: MATH 211 AND CSE 330

Recent developments in computational intelligence, a discipline which encompasses ideas from neural networks, fuzzy logic, evolutionary computation and in general from soft-computing areas. Solving real-world problems that are difficult to solve using traditional techniques. Includes optimization, pattern recognition, learning, decision making and prediction. Formerly offered as a topic under CSE 594.

### **CSE 515. Automated Reasoning. 4 Units.**

Prerequisites: CSE 431

Study of deduction algorithms for expert systems and the limitations thereof, propositional calculus, quantification theory, completeness and incompleteness theorems, Herbrand-Gödel computability, resolution principle, equality and inequality relations.

### **CSE 516. Machine Learning. 4 Units.**

Prerequisites: CSE 330

Theory and practice of machine learning techniques, including supervised learning, unsupervised learning, reinforcement learning, and learning in multi-agent systems. Three hours lecture and two hours activity laboratory. Formerly a topic under CSE 594, students may not receive credit for both CSE 516 and CSE 594 for those terms in which Machine Learning was the topic. Materials fee required.

### **CSE 520. Advanced Computer Graphics. 4 Units.**

Prerequisites: CSE 420

Advanced computer graphics concepts, theory and implementation techniques. Topics include shading models, parametric curves and surfaces, hidden edge and surface removal, and anti-aliasing.

### **CSE 521. Field Programmable Gate Array Design. 4 Units.**

Prerequisites: CSE 401

FPGA design rules, timing, latency, optimizations, ASIC conversion, state machines, implementing arithmetic, counters, memory, error detection and correction, simulation, and layout. Materials fee required. Three hours lecture and three hours laboratory.

### **CSE 524. Supercomputing and Visualization. 4 Units.**

Prerequisites: CSE 330 or consent of instructor

Design and implementation of scientific applications on high performance computers emphasizing graphics and visualization techniques. Topics include parallel algorithm development, multiprocessor and multicompiler programming, and real-time visualization programming of computationally intensive problems in the sciences.

### **CSE 525. Parallel Algorithms and Programming. 4 Units.**

Prerequisites: CSE 401

Topics include algorithm design, analysis, and programming of high performance computers. Also covered are control-parallel versus data-parallel approaches, PRAM algorithm design, and selected parallel programming languages. Four hours lecture.

### **CSE 530. Data Communications and Networks. 4 Units.**

Prerequisites: CSE 313 or 598, and 330

Topics include baseband and broadband signals and modulation schemes. Error detecting and correcting codes, ISO protocol standard, packet switching and various local network schemes. Three hours lecture and two hours activity laboratory. Materials fee required. Formerly CSE 430.

### **CSE 531. High Performance Networks. 4 Units.**

Prerequisites: CSE 530 or consent of instructor

High performance network methodologies. Methods to develop network performance measures and models. Introduction to path cost estimation and service reliability issues. Three hours lecture and two hours laboratory. Materials fee required.

### **CSE 535. Numerical Computation. 4 Units.**

Prerequisites: MATH 331

Introduction to scientific computing. Algorithms related to approximations, zero findings, numerical differentiation and integration, data fitting and interpolation, nonlinear equations. Three hours lecture and two hours laboratory. Materials fee required.

### **CSE 541. Robotics and Control. 4 Units.**

Prerequisites: CSE 310 and CSE 313

Theory and practice of robotic modeling, control, programming, and construction. Three hours lecture and three hours laboratory. Materials fee required.

### **CSE 550. Advanced Bioinformatics I: Sequence Analysis. 4 Units.**

Prerequisites: CSE 431 and senior standing or consent of instructor  
Pairwise and multiple sequence alignment of strings and relations to biology. Building phylogenetic trees from sequences. Predicting and analyzing RNA secondary structure. Three hours discussion and two hours activity.

### **CSE 551. Advanced Bioinformatics II: Numerical Modeling. 4 Units.**

Prerequisites: CSE 535

Numerical techniques for the modeling and simulation of biological and chemical systems using ordinary and partial differential equations, and stochastic variables. Three hours discussion and two hours activity.

### **CSE 555. Software Design and Architecture. 4 Units.**

Prerequisites: CSE 330

Common patterns of architectural design, tradeoff analysis at the architectural level, domain-specific architectures, automatic support for architectural design, and formal methods of software architecture. Three hours lecture and two hours laboratory.

### **CSE 557. Computer Systems in Organizations. 4 Units.**

Prerequisites: CSE 330, MATH 262, or consent of instructor

General system and information theory. Modeling organizations, activities, hardware, data, and software using current techniques with emphasis on human-computer interaction, systems engineering and project planning. Students will study parts of actual organizations. Formerly CSE 372.

### **CSE 558. Requirements Analysis and Design. 4 Units.**

Prerequisites: CSE 330 or consent of instructor

Requirements analysis, including organizational objectives, functions, use cases, and domain models. The use of objects, patterns, objects and layers in architectural design specifications. Includes analysis, design and implementation of a software system using an agile software process. Three hours lecture and two hours activity laboratory. Materials fee required. Formerly CSE 375.

### **CSE 565. Systems Programming. 4 Units.**

Prerequisites: CSE 460

Concepts of, and implementation techniques for systems software such as assemblers, editors, interpreters, linkers, loaders and operating systems. Formerly CSE 465.

### **CSE 570. Compilers. 4 Units.**

Prerequisites: CSE 313 and CSE 330

Interpreter and compiler structures. Topics include symbol tables, lexical and syntactic analyzers, and object code generation. Three hours lecture and two hours activity laboratory. Materials fee required. Formerly CSCI 470.

### **CSE 572. Database Systems. 4 Units.**

Prerequisites: CSE 330

Basic concepts of database design and theory, including underlying storage structures and alternative approaches to database models (relational, object-relational, network and hierarchical). Hands-on applications with one or more commercial database management systems. Three hours lecture and two hours activity laboratory. Materials fee required.

### **CSE 575. Internship in Computer Science. 4 Units.**

Prerequisites: a minimum grade point average of 3.0 and departmental approval of a written proposal submitted on a standard application filed in advance of the quarter in which the course is to be taken  
Supervised work and study in private or public organizations. Graded credit/no credit.

### **CSE 580. Advanced Database Systems. 4 Units.**

Prerequisites: CSE 572

Advanced study of components of general database systems and other topics such as implementation methods, query language design, reliability, integrity, performance measures, distributed database systems and database machines. Three hours lecture and two hours activity laboratory. Materials fee required.

### **CSE 594. Topics in Computer Science. 4 Units.**

Prerequisites: CSE 330 or consent of instructor

An in-depth consideration of selected areas of computer science. May be repeated for credit as topics change. Formerly CSCI 494, credit may not be received twice for the same topic.

### **CSE 595A. Independent Study. 1 Unit.**

Prerequisites: a minimum overall grade point average of 3.0, consent of instructor and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken

Laboratory and/or library research conducted under the direction of a faculty member. A total of four units in CSE 595 may be applied toward the computer science, computer systems, computer engineering, and bioinformatics majors.

### **CSE 595B. Independent Study. 2 Units.**

Prerequisites: a minimum overall grade point average of 3.0, consent of instructor and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken

Laboratory and/or library research conducted under the direction of a faculty member. A total of four units in CSE 595 may be applied toward the computer science, computer systems, computer engineering, and bioinformatics majors.

### **CSE 595C. Independent Study. 3 Units.**

Prerequisites: a minimum overall grade point average of 3.0, consent of instructor and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken

Laboratory and/or library research conducted under the direction of a faculty member. A total of four units in CSE 595 may be applied toward the computer science, computer systems, computer engineering, and bioinformatics majors.

### **CSE 595D. Independent Study. 4 Units.**

Prerequisites: a minimum overall grade point average of 3.0, consent of instructor and departmental approval of a written proposal of a project submitted on a standard application filed in advance of the quarter in which the course is to be taken

Laboratory and/or library research conducted under the direction of a faculty member. A total of four units in CSE 595 may be applied toward the computer science, computer systems, computer engineering, and bioinformatics majors.

### **CSE 602. Computation and Complexity Theory. 4 Units.**

Prerequisites: CSE 500 or consent of instructor

Theoretical foundations of computer science: deterministic and non-deterministic Turing machines, models of computation; recursive functions, Church's thesis and undecidable problems; complexity classes P, NP, CO-NP and PSPACE. May not be taken for credit by students who have received credit for CSE 501, CSE 546, CSE 646. Formerly CSE 600.

### **CSE 603. Advanced Computation and Complexity Theory. 4 Units.**

Prerequisites: CSE 602 or consent of instructor

Advanced topics in theoretical foundations of computer science: models of computation; recursive functions; Church's thesis and undecidable problems; complexity classes P, NP, CO-NP and PSPACE. Formerly CSCI 601 and 646.

### **CSE 610. Modern Computer Architecture. 4 Units.**

Prerequisites: CSE 401 or consent of instructor

Study of the elements and construction of advanced computer systems, including parallel systems, vector processors, network scheduling, pipelining, array processors, and systolic arrays. May not be taken for credit by students who have received credit for CSE 510. Three hours lecture and two hours laboratory. Materials fee required.

### **CSE 611. VLSI Circuit Design. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Fundamental design techniques for Very Large Scale Integrated (VLSI) circuits; physics of semi-conductor devices; design rules and circuit layouts; use of computer-aided design tools for design, layout and testing. Three hours lecture and two hours laboratory. Materials fee required.

### **CSE 620. Programming Languages Theory. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Theory of programming languages, including implementation details, the required machine and data structures needed for user interfaces, coded parallelism, distributed processing facilities, functional and object oriented programming languages. Three hours lecture and two hours laboratory. Materials fee required.

### **CSE 621. Contemporary Computer Graphics. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Theory and practice of modern graphics techniques. Topics include 3-D modeling, interaction, ray tracing, object representation, visualization, and animation techniques.

### **CSE 624. Distributed Computer Systems. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Open Systems Interconnection (OSI) transport, presentation and application layers; distributed control; access methods; reliability; heterogeneity; resilience; applications in network operating systems, distributed operating systems and distributed database systems.

**CSE 625. Multiprocessor and Parallel Processing. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Tightly and loosely coupled multiprocessors; interconnection network; parallel programming languages; scheduling; problem decomposition; operating systems; performance; synchronization and communication; user-interface and programming environment; multiprocessor machine programming. May not be taken for credit by students who have received credit for CSE 525.

**CSE 630. Theory of Algorithms and Their Analysis. 4 Units.**

Prerequisites: CSE 431 or consent of instructor

Algorithmic techniques, construction, time and space complexities, properties of taxonomic classes; survey of processing algorithms for graphs, trees, sets, and sequences; algebraic, numeric and geometric analysis techniques; dynamic programming, randomized algorithms, parallel algorithms; NP.

**CSE 631. Advanced Data Communications. 4 Units.**

Prerequisites: CSE 530 or consent of instructor

Topics include high bandwidth networks, formal models of network performance, traffic and congestion control, formal routing theory, quality of service, and internet protocol suite adaptations to high bandwidth networks. May not be taken for credit by students who have received credit for CSE 531. Three hours lecture and two hours laboratory. Materials fee required.

**CSE 634. Neural Networks. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Theory and applications of neural networks; current developments; perceptrons; Hopfield networks; self-organizing mappings and content-addressable memories; multi-layer networks.

**CSE 635. Numerical Algorithms and Simulation. 4 Units.**

Prerequisites: CSE 535 or equivalent

Scientific computing and simulation. Systems of linear equations, linear least squares, backward error analysis and numerical stability, stiff equations, simulation, sparse matrices. Three hours lecture and two hours laboratory. Materials fee required.

**CSE 640. Artificial Intelligence. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Knowledge representations; heuristics; theory of problem solving; adaptive systems; natural language understanding; automatic theorem proving; learning and robotics systems. Three hours lecture and two hours laboratory.

**CSE 655. Software Engineering Concepts. 4 Units.**

Prerequisites: CSE 455, 555, or 556 or consent of instructor

Analyses of software requirements definitions, software systems design, implementation issues, verification and validation, and software maintenance techniques; rapid prototyping procedures; operational and transformational paradigms of software development; software engineering models and CASE tools including reverse engineering and module reusability concepts; applications in object-oriented programming languages. Three hours lecture and three hours laboratory. Materials fee required.

**CSE 656. Formal Methods, Models and Languages. 4 Units.**

Prerequisites: classified status

Applications of logic and mathematics in documenting problems, requirements, specifications, designs, and software. Formal modeling languages. Diagrammatic, algebraic, and tabular models. Model checking. Students prepare, check, and present models using techniques in the literature for a research paper. Students may not receive credit for both CSE 556 and 656. Three hours lecture and two hours activity laboratory. Materials fee required.

**CSE 660. Operating Systems Concepts and Theory. 4 Units.**

Prerequisites: CSE 460 or consent of instructor

Operating system concepts and scheduling practices, including security, real time, multiprocessing, resource sharing, distributed file systems and peripherals access scheduling; distributed processing environments and parallel processing facilities. Three hours lecture and two hours laboratory. Materials fee required.

**CSE 670. Compiler Design Theory. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Compiler design for block structures, general purpose programming languages; automatic generation of lexical analyzers and parsers; error detection and correction; code optimization. Three hours lecture and two hours laboratory. Materials fee required.

**CSE 671. Advanced Compilers. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor. An introductory course in compilers is recommended. Intermediate code generation, optimization, object code generation and architecture and optimized compiler co-design.

**CSE 680. Distributed Database Management Systems. 4 Units.**

Prerequisites: graduate standing in computer science or consent of instructor

Distributed database issues including methods of data distribution, types of remote database access, concurrency management, extensions to Structured Query Language (SQL) for remote databases, cooperative processing, database machines and intelligent databases. May not be taken for credit by students who have received credit for CSE 580. Three hours lecture and two hours activity laboratory. Materials fee required.



**CSE 689. Comprehensive Examination. 1 Unit.**

Prerequisites: CSE 600, CSE 610, CSE 630, CSE 655, CSE 660 and consent of graduate coordinator

Unsupervised study in preparation of the comprehensive examination.

Topics include the material covered in the core courses: formal language and automata theory, computer architecture, algorithms, software engineering, and operating systems. May be repeated only once. Graded credit/no credit.

**CSE 690B. Masters Project. 2 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate project conducted under the guidance of a major advisor; total of at least five units of CSE 690 must be taken in contiguous quarters.

**CSE 690C. Masters Project. 3 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate project conducted under the guidance of a major advisor; total of at least five units of CSE 690 must be taken in contiguous quarters.

**CSE 690D. Masters Project. 4 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate project conducted under the guidance of a major advisor; total of at least five units of CSE 690 must be taken in contiguous quarters.

**CSE 690E. Masters Project. 5 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate project conducted under the guidance of a major advisor; total of at least five units of CSE 690 must be taken in contiguous quarters.

**CSE 695B. Graduate Independent Study. 2 Units.**

Prerequisites: graduate standing in computer science, consent of instructor, and approval of a written proposal of the research by the department graduate program coordinator

Independent graduate research in computer science. A total of four units in this course may be applied toward the M.S. degree.

**CSE 695C. Graduate Independent Study. 3 Units.**

Prerequisites: graduate standing in computer science, consent of instructor, and approval of a written proposal of the research by the department graduate program coordinator

Independent graduate research in computer science. A total of four units in this course may be applied toward the M.S. degree.

**CSE 695D. Graduate Independent Study. 4 Units.**

Prerequisites: graduate standing in computer science, consent of instructor, and approval of a written proposal of the research by the department graduate program coordinator

Independent graduate research in computer science. A total of four units in this course may be applied toward the M.S. degree.

**CSE 698A. Continuous Enrollment for Graduate Candidacy Standing. 1 Unit.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 698B. Continuous Enrollment for Graduate Candidacy Standing. 2 Units.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 698C. Continuous Enrollment for Graduate Candidacy Standing. 3 Units.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 698D. Continuous Enrollment for Graduate Candidacy Standing. 4 Units.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 698E. Continuous Enrollment for Graduate Candidacy Standing. 5 Units.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 698F. Continuous Enrollment for Graduate Candidacy Standing. 6 Units.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 698Z. Continuous Enrollment for Graduate Candidacy Standing. 0 Units.**

Prerequisites: advancement to candidacy and approval of program graduate coordinator or, if an interdisciplinary studies major, consent of the Dean of Graduate Studies

Independent study leading to completion of requirements (other than course work) for the master's degree. To retain classified standing in the master's program, a student must enroll in 698 each quarter until the project or thesis is accepted or the comprehensive examination passed. Students who enroll in 698 through the university have full use of all university facilities. See Culminating Experience: Exam, Thesis, or Project in Graduate Degree and Program Requirements section of the Bulletin of Courses. 698 is a variable unit course, see fee schedule in the Financial Information section of the Bulletin of Courses. Earned units are not degree-applicable nor will they qualify for financial aid.

**CSE 699B. Thesis. 2 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate research conducted under the guidance of a major advisor; total of at least nine units for CSE 699 must be taken in contiguous quarters.

**CSE 699C. Thesis. 3 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate research conducted under the guidance of a major advisor; total of at least nine units for CSE 699 must be taken in contiguous quarters.

**CSE 699D. Thesis. 4 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate research conducted under the guidance of a major advisor; total of at least nine units for CSE 699 must be taken in contiguous quarters.

**CSE 699E. Thesis. 5 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate research conducted under the guidance of a major advisor; total of at least nine units for CSE 699 must be taken in contiguous quarters.

**CSE 699F. Thesis. 6 Units.**

Prerequisites: advancement to candidacy and consent of department major advisor

Independent graduate research conducted under the guidance of a major advisor; total of at least nine units for CSE 699 must be taken in contiguous quarters.